
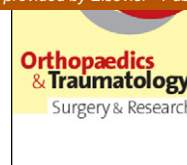




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ORIGINAL ARTICLE

Primary aseptic revision of the femoral component of a cemented total hip arthroplasty using a cemented technique without bone graft

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KEYWORDS

Total hip arthroplasty;
Revision;
Femoral stem;
Cement

Summary

Background: Primary revisions using cement without bone graft reconstruction are less frequently used because of their supposed higher failure rate. The results, in fact, depend on multiple parameters: number of prior revisions, cementing technique quality, and residual bone stock; these intricate factors are rarely taken together into account when analyzing this treatment method.

Hypothesis: Femoral component fixation with cement can be a valid option in total hip arthroplasty primary revision.

Objectives: The objective of this investigation was to study the long-term results of cemented femoral stems in total hip arthroplasty primary revisions in terms of the quality of the cementing technique and the residual bone stock.

Patients and methods: This is a retrospective study of a series of 80-cemented primary femoral stems revised for aseptic loosening using a new-cemented femoral stem without bone graft. Seventy implants were analyzed at the longest follow-up. The Postel Merle D'Aubigné and the Harris Hip Scores were used for clinical assessment. The French Academy SOFCOT 99 bone loss grading system was used to classify preoperative bone compromise severity. The Barrack classification assessed the quality of the postoperative cementation. The radiographic study at the last follow-up sought signs of femoral implant loosening classified according to Harris.

Results: The mean follow-up was 10 years and 10 months. The functional evaluation of the hip showed a significant overall gain ($p < 0.0001$) after surgical revision. In our series, the existence of severe grade III or IV bone loss on the SOFCOT 99 classification exposed the patient to a significant risk of intraoperative complications ($p = 0.03$). The grade III and IV femurs had a significantly higher risk ($p = 0.0001$) of having type C or D cementation according to the Barrack classification. Type D cementation was a risk factor for significant iterative radiographic loosening ($p = 0.005$) compared to A, B or C cementations. The 10-year survival rate of the femoral implant was 90% (95% confidence interval [95% CI]: 79.2–94.9%). This survival rate was significantly better

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($p=0.0016$) for revisions with type A or B cementations on the Barrack scale (96% survival; 95% CI: 85.1–99%) than for type C or D (70% survival; 95% CI: 41.4–86.1%).

Conclusion: This study shows that revised cemented femoral stems without bone graft added are a valid therapeutic option in primary cemented total hip arthroplasty revisions provided that a good-quality cement technique can be achieved. Sufficient bone stock (SOFcot 99 grade 0, I or II) was indispensable for good cementation.

Level of evidence: IV: therapeutic retrospective study.

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Introduction

In the 1980s, the results published on total hip arthroplasty revisions with a cemented femoral stem showed a survival rate for the femoral implant that was much lower than for primary implants, with 30% failure for revision or loosening at 8 years [1,2]. At the end of the 1990s, new cementing techniques [3] made it possible to obtain better results with survival rates greater than 90% at 10 years [4]. The objective of this study was to investigate the long-term results of the cemented femoral stem in the primary revisions of total hip arthroplasties in light of cementation quality and bone stock.

Patients and methods

Patients

This was a retrospective study of a series of cemented femoral stem revisions of cemented total hip arthroplasties. One hundred and fifty-five revisions of total hip arthroplasties for aseptic loosening were performed in our department between 1993 and 1996. Revisions for fracture, revisions of cementless femoral stems, revisions with placement of cementless femoral stems, as well as repeated revisions were excluded.

The series therefore comprised 80 implants for 74 patients (six patients had bilateral revision): 50 women and 24 men. The mean age at the time of the intervention was 68 years (range: 41–83 years), with a mean body mass index of 25.7 (range: 18.8–34.3).

The initial hip arthroplasty was performed for idiopathic osteoarthritis in 45 cases (56%), arthrosis secondary to dysplasia in 21 cases, osteonecrosis of the femoral head in four cases, ankylosing spondylarthritis in both hips of one patient, acetabulum fracture in one case, revised hip arthrodesis in one case, and in six cases the etiology was unknown (absence of initial radiograph). The time between implantation of the former femoral stem and its revision was a mean 11 years and 3 months, with a standard deviation (S.D.) of 5.5 years (range: 3–26 years).

The causes for arthroplasty revision were 41 cases of bipolar loosening, 25 cases of isolated femoral loosening, and 14 cases of acetabular loosening (with the decision to change the femoral implant as a matter of principle made during the preoperative planning stage because of the long follow-up of the femoral implant or upon observation of stem loosening during the procedure).

The severity of bone loss was judged on preoperative Antero-Posterior (AP) radiographs of the pelvis and AP and lateral radiographs of the full femur using the SOFCOT 99 classification, which clearly established cortex thickness by individualizing the lateral and medial cortex as well as the Merkel area and lesions of the greater trochanter rated by adding "T0 to T2" to the femoral score [5]. Likewise, deformities of the femoral shaft were rated by adding "V" to the femoral score [5]. The series comprised 12 stage 0, 36 stage I (two T1), 16 stage II (four T1, one V T0 with 8° varus deformation of the femur shaft) patients, 14 stage III (three T1, three T2, one V T0 with 10° varus deformation of the femur at the distal end of the stem) patients, and two stage IV (one T1, one T2) patients (Fig. 1).

Evaluation methods

Stem extraction and its complications, cement ablation and its complications, any bone grafts, the type and length of the implanted stems, the cementing technique, the duration of surgery and the quantity of blood loss, the complications occurring during hospitalization, and the time to weightbearing were noted. Clinical assessment was based on preoperative consultation reports, 6 months after the

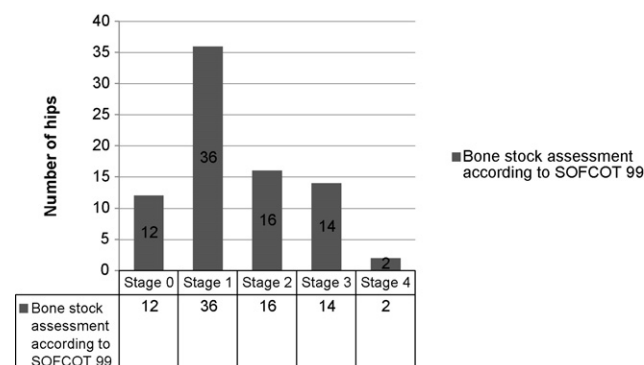


Figure 1 Distribution of bone substance loss according to the SOFCOT 99 criteria [5]. Stage 0: no lesion; stage I: thinned but satisfactory cortex with more or less severe lysis of the Merkel cells; stage II: lateral cortex highly thinned, medial cortex thinned but satisfactory; stage III: lateral cortex highly thinned, medial cortex partially destroyed under the lesser trochanter; stage IV: femur pellucid or disappeared. Complementary lesions with suffix: T0: trochanter intact, T1: fractured trochanter consolidated, T2: trochanter fractured or nonunion, V: presence of diaphyseal varus greater than 5°.

Table 1 Radiological classification of cementation according to Barrack et al. [8].

Grade A	Medullary cavity entirely filled with cement, bone–cement interface shows no radiolucencies
Grade B	Radiolucent line at the bone–cement interface over at least 50% of the surface
Grade C	Radiolucent line at the bone–cement interface over 50–99% of the surface or presence on an incomplete cement mantle (cement not covered in one area)
Grade D	Radiolucent line at the bone–cement interface over 100% of the surface or stem extremity not covered with cement

surgery and at the last follow-up using the Postel Merle d'Aubigné (PMA) numbered classification [6] and the Harris Hip Score [7]. Radiographic assessment was based on AP and lateral pelvic films taken 6 months after the intervention. Any angle deviation of the femoral stem in the frontal plane (varus, valgus) taking into account that the stems were aligned when their deviation was included between valgus less than or equal to 5° and varus less than or equal to 5°. Good-quality cementation was judged according to the Barrack et al. [8] radiographic classification (Table 1).

Radiographic loosening of the femoral stems was classified according to the criteria defined by Harris et al. [9]:

- “definite loosening” is defined by the single criterion of implant migration shown by the presence of one or several radiographic images with a visible change in the femoral component or the cement mantle or both, an image of cement or femoral stem fracture or a radiolucent line between the stem and the cement that were not on the postoperative X-rays;
- “probable loosening” is defined by the presence of a continuous radiolucent line at the bone–cement interface, surrounding the entire cement mantle on the AP and lateral X-rays;
- “possible loosening” is arbitrarily defined by the presence of a radiolucent line at the bone–cement interface occupying more than 50% but less than 100% of the perimeter of the interface on the AP and lateral films, this line could not be present on the immediate postoperative radiographs.

Femoral stem migration on the radiographs at the last follow-up compared to those taken 6 months after the intervention was sought by measuring the distance between the great trochanter and the center of the femoral head and between the great trochanter and the lateral shoulder of the femoral stem.

Statistical methods

A Kaplan-Meier survival curve was calculated first on the entire series, taking surgical revision of the femoral stem for any reason as the criterion for failure. Then, the different groups were compared: the patients with good cementa-

Table 2 Overall Merle d'Aubigné functional score [6]^a.

	Preoperative score	Score at 6 months	Score at last follow-up
Mean	10.4	16.6	15
Standard deviation	2.9	1.4	3.4
Minimal	2	11	4
Maximal	15	18	18

^a There was significant gain ($p < 0.0001$) between the preoperative score and the score at 6 months and at the last follow-up.

tion (Barrack grades A and B) and the patients with less satisfactory cementation (Barrack grades C and D). The Wilcoxon-Breslow test was used on the survival curve results to determine whether there was a significant difference between the groups. The qualitative variables were compared using the Chi-square test. If the conditions were not respected we used the Fisher exact test. $P < 0.05$ was considered as significant.

Results

Clinical results

Ten cases were declared lost to follow-up out of the 80 initially studied. The mean follow-up for the 70 remaining implants was 10 years and 10 months (range: 1–13.3 years; S.D.: 2.5 years). The overall PMA score was a mean 15 at the last follow-up (Table 2). The overall Harris Hip Score was a mean 76.8 at the last follow-up (Table 3). There was a significant gain ($p < 0.0001$) between the preoperative PMA score and the PMA at the last follow-up (as between the preoperative and last follow-up Harris Hip Scores).

Approach and intraoperative complications

The posterolateral approach was used in all cases. The explanted stems were all cemented stems shorter than 180 mm. In 73 cases, stem extraction was unproblematic; in two cases, it required performing a metaphyseal–diaphyseal femoral flap (Extended Trochanteric osteotomy). In four cases, a distal cortical window was performed: two for ablation of the plug, two for extraction of the cement. In principle, the cement extraction was attempted via an endomedullary approach, from proximal to distal.

Table 3 Harris Hip Score [7]^a.

	Preoperative score	Score at last follow-up
Mean	44.4	76.8
Standard deviation	13.7	20.9
Minimal	2	23
Maximal	66	99

^a There was significant gain ($p < 0.0001$) between the preoperative score and the score at 6 months and at the last follow-up.

Thirteen intraoperative surgical complications (16%) were reported: eight erroneous pathways, five relatively large perforations possibly weakening the femur but not disrupting the overall cortex continuity. SOFCOT 99 stage III or IV bone loss was a significant risk factor for intraoperative complications ($p=0.03$).

Types of pivot, postoperative conditions, and long-term complications

For reimplantation, we used stems that were less than 180 mm long in 26 cases (22 Charnley Kerboul 3TM classics, four Charnley Kerboul 2TM dysplastic stems). The long implanted stems were revision AthenaTM pivots in 31 cases, revision Charnley KerboulTM in 16 cases, six long Charnley stems, and one LubinusTM Link stem. None of the stems described as short was implanted on SOFCOT 99 stage III or IV femurs. Out of the 26 short stems, 21 were implanted in femurs classified as SOFCOT 99 T0 or T1 ($p=0.01$). The implanted heads were 28 mm in diameter. In all cases, the cementing technique used a distal endomedullary plug, high-viscosity PalacosTM cement, and a retrograde introduction of the cement using a syringe with a long adaptor. The procedure lasted a mean 300 min (range: 120–420 min). Blood loss was a mean 2300 mL (range: 600–5000 mL).

Hospitalization lasted a mean 19 days (range: 10–79 days). The complications during hospitalization were two cases of popliteal venous thrombosis, three delays in spontaneous healing that resolved during hospitalization, and two hematomas. Complete resumption of weightbearing was possible on the third day after surgery, with crutches, in 59 cases (74%) and after a 6-week period of nonweightbearing for 11 patients (14%) and after 3 weeks of bedrest followed by nonweightbearing for another 3 weeks for six patients. In four cases, the patients had to observe complete nonweightbearing for 3 months for assemblies that were judged to be fragile. No dislocations were found for any of the implants during this first 3-month period.

Over time, other complications occurred: four (5.7%) out of the 70 hips studied underwent at least one episode of dislocation, two female patients had a fracture of the femur under their prosthesis (one 6 months after the intervention, the other 6 years after), both had been treated with a plate secured with wiring. At the last follow-up, these two stems showed radiographic loosening.

Radiographic results

Seventy-nine stems were considered to be aligned. For 62 femoral stems out of 80, the cementation results were grade A or B (Fig. 2). The stage III or IV femurs on the SOFCOT 99 index had a significantly higher risk of having grade C or D cementation on the Barrack classification ($p=0.0001$). Fifty percent of the stage III or IV femurs had grade C or D cementation results.

At the radiographic evaluation at the longest follow-up, 53 cases presented no migration. We found one case of stem migration with its cement mantle that had sunk 2 mm into the femoral shaft compared to the position on the postoperative X-rays. In three other cases, the stem had migrated in

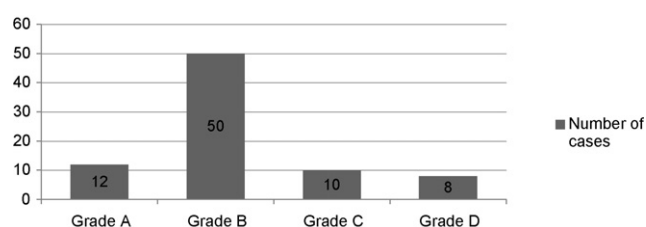


Figure 2 Distribution of the 80 cases operated on according to the Barrack et al. classification [8].

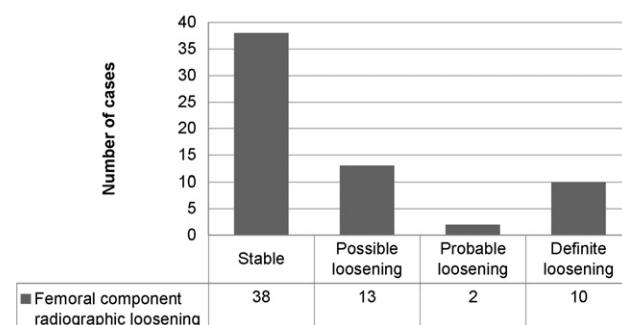


Figure 3 Distribution of the 63 cases (10 lost to follow-up and seven femoral stems changed) in relation to their loosening status according to Harris et al. [9].

relation to the cement. These migrations were not present on the films 6 months after surgery (Fig. 3).

According to the Harris radiographic criteria, 10 implants had loosened (definite loosening according to the Harris criteria). The 10 implants associated the four cases of migration with six cases presenting a radiolucent line at the cement–prosthesis interface, which did not show up on the X-rays at 6 months. Grade D cementation was a risk factor of significant repeated radiological loosening ($p=0.005$) compared to grade A, B or C cementation.

Survival analysis

At the last follow-up, 90% of the 70 femoral stems were still in place. Seven femoral stems had been revised, six stems for aseptic loosening and one stem for septic loosening 8 years after the intervention. The mean time to a new revision was 8 years. The survival rate at 10 years, with the stem change as end-point, was significantly better ($p=0.0016$) for the stems with grade A or B cementing according to the Barrack classification (96% survival; 95% CI: 85.1–99%) compared to the stems with grade C or D cementation (70% survival; 95% CI: 41.4–86.1%).

Discussion

The study confirms the value of cemented revision in terms of functional recuperation. In this series, 74% of the patients had arthroplasty revision with complete weightbearing on their lower limb as early as the third day after surgery. The rate of intraoperative complications stemming from problems extracting the cement was high (16%), but it is comparable to the SOFCOT 99 rate [10]. The mechanical cement extraction methods (Stühmer-, Moreland- or

Juillard-type intracanal aiming systems, diaphyseal aiming systems such as the Atlanta and the Segmental Cement Extraction System or the techniques using ultrasound) did not prove to be superior, with 28.6% fracture and erroneous pathway rates versus 18% for conventional methods [11]. The SOFCOT 99 symposium showed that the intraoperative fracture rate increased with the amount of bone loss evaluated on preoperative radiographs. The mean duration of long surgeries in our series (300 min), the mean blood loss (2.3 L) are explained by the purely endomedullary cement ablation. In their series of cemented stem femoral revisions with bone graft, Marmorat et al. [12] found that surgery lasted 320 min with blood loss at 2 L. The mean hospital stay of 19 days was explained by the availability of convalescence centers where patients were systematically sent at the time.

The functional evaluation of the hip showed a significant gain ($p < 0.0001$) after surgical revision with an overall PMA score improving from 10.4 points preoperatively to 15 at the last follow-up. Similarly, the overall Harris Hip Score improved significantly ($p < 0.0001$) from 44.4 before surgery to 76.8 at the last follow-up. This corresponds to a good clinical result, as demonstrated by the SOFCOT 99 symposium [13], which found no significant differences in the overall PMA score between different types of implant (cemented or uncemented).

The sum of the poor results in our series (revisions for loosening, 10%; definite radiological loosening, 15.8%) is within the mean of the published results (Table 4). However, these results are difficult to compare. Some authors report revision rates [4, 14], while others report loosening rates with or without infection [15–17]. Some studies investigated primary revisions [15], whereas others studied patients who had undergone one or several revisions of their femoral stem before inclusion [14, 18–20].

Similarly, the initial bone stock is difficult to evaluate and therefore to compare from one study to another because of the multiplicity of the classifications used: Endoklinik for Hultmark et al. [15], Mallory for Haydon et al. [14], and SOFCOT for Migaud et al. [5]. However, the SOFCOT 99 symposium [21] showed that the initial bone stock influenced the results of revisions and underscored the relation between bone stock and cementing quality and therefore the implant's longevity.

In our series, there was a highly significant difference ($p = 0.001$) between the stems classified as A or B according to the Barrack classification and grade C or D stems in terms of the implant's 10-year survival rate, with the criterion being stem change failure (96% versus 70%). This point had already been published by Haydon et al. [14] as well as by Eisler et al. [16] and Nouri et al. [22].

Estok and Harris [18] reported that grades A and B (excellent and good cementation) were found in 100% of the primary arthroplasties and in only 60% of total hip arthroplasty revisions. Hultmark et al. [15] made the same observation. In our series, we also found a low rate of good cementation in a series of primary cemented revisions, with only 15% grade A with a correlation between cementing quality and bone stock quality. In our study, the SOFCOT 99 stage III and IV femurs had a significantly higher risk of having a poor grade C or D cementation according to the Barrack classification ($p = 0.0001$).

Table 4 Results of the series of cemented femoral revisions without bone reconstruction.

Authors	Year of publication	Types of follow-up	Mean follow-up (years)	Number of hips studied	Age at revision	Primary revisions or repeated revisions	Types of revision stem: cemented or uncemented	Percentage of new revisions at longest follow-up (%)	Percentage of definite radiological loosening at longest follow-up (%)
Haydon et al. [14]	2004	Retrospective	10.3	97	68	Both	Both	13	6
Gramkow et al. [17]	2001	Retrospective	10	84	69	Primary revisions	Not specified	16.6	19
Eisler et al. [16]	2000	Retrospective	3.6	83	70	Primary revisions	Not specified	6	33
Hultmark et al. [15]	2000	Prospective	10	109	71	Primary revisions	Both	6.4	11
Nouri et al. [22]	2008	Retrospective	4.4	28	59	Primary revisions	Cemented	14	21
Raut et al. [4]	1995	Retrospective	6	351	64	Both	Not specified	5.7	Not specified
Estok et al. [18]	1994	Retrospective	11.7	38	52.8	Both	Not specified	10.5	10.5
Huten et al. [20]	2000	Retrospective	6.8	372	68	Both	Both	8.1	Not specified

The problem with removing all of the interposition tissue (cement and granuloma) and preoperative bone loss are two of the possible causes of inferior quality cementation in revisions. It is technically more difficult to completely fill a wider femoral shaft presenting a number of cavities. Some authors have also questioned the length of revision stems as a cause of poor cementing. They explain this by the fact that a long stem extends beyond the hourglass constriction of the femur and makes the use of an intramedullary plug impossible or at least less effective. In a clinical study, Repten and Jensen [23] showed that the survival rate of a cemented revision femoral stem was improved if this stem extended beyond the zone of bone loss a distance equal to the diameter of the femoral shaft. This was validated experimentally Panjabi et al. [24]. However, Gramkow et al. [17] did not find a better survival rate for their stems that were longer than 210 mm compared to those that were shorter than 210 mm. In our study, six of the eight grade D cementations were classified as such for stems longer than 240 mm whose tip was not covered in cement. Indeed, these stems accumulated problems. They combined mediocre cementing of their proximal part at a zone presenting significant osteolysis with a distal tip that was not or only partially covered in cement.

Conclusion

This study shows that cemented revision femoral stems without bone graft are a good therapeutic option in primary cemented total hip arthroplasty revision provided that good-quality cementation can be achieved. Sufficient bone stock (SOFCOT 99 stage 0, 1 or 2) is indispensable to proper cementation.

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